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REVIEW ARTICLE

Processing Nervous Signals through Functional Neuro Electrical Stimulation

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ABSTRACT

Today most of them rely on Man Machine Interfaces (MMI) to extract the information required by them. When this is the situation, we need to use efficient real time algorithms which can interpret nervous signals and process them as required. The most important aspect is to induce the information into nervous system with the help of Functional Neuro Electrical Simulation (FNS). This paper would give you an introduction about man machine interface and also provides the review of MMI development using neural networks and Machine Learning (ML) for signal processing systems.
Keywords: MMI, Real time algorithms, Nervous systems, FNS, Neural networks, Machine learning.

1. INTRODUCTION

Earlier in 1497 itself Alessandro Benedetti realized that the nerves that serve as the sense paths are dispersed as that of roots and fibers of a tree even though the fundamentals of biophysics related to the nervous system were unidentified at that time. Likewise, in 4th century Aristotle stated that the nerves originate from the heart which also keeps the nerves in control and that plays a major role in motion and sensation. Then after six centuries, Roman physician Galen also confirmed to Aristotle’s statement stating that the brain serves as the most significant part of the body. Later in 1681, Thomas Willis framed the word, neurology which refers to the study of Neuro-anatomy. Even after the late 18th century physiologists linked the latest works on electricity and theories corresponding to the nervous system. In 20th century, Berger invented electroencephalogram that aids in observing the neuronal activities of the brain.

Adrian and Bronk utilized the concentric needle electrodes to monitor the motor units, whereas Berger used surface electrodes to record neuronal activities by placing them over the scalp. Nerve cell acts electrically as well as chemically, where each of their endings is provided with synaptic points that consist of numerous tiny membranous sacs to carry neurotransmitter chemicals. These chemicals are responsible to transmit the nerve impulse from a nerve cell to another which reaches the point by passing through a neuron and activates the neurotransmitters from their sacs. On moving along the synapse, the neurotransmitters activate or stimulate electric charge in order to carry the impulse further. It is continued till a muscle gets relaxed or the brain records a sensory impression. This action, by how the information gets passed from one location of the body to other is observed as the language of nervous system.

The information that leaves the central nervous system (CNS) is conveyed by the peripheral nervous system (PNS). It is comprised of cranial and spinal nerves that send the information from receptor cells to the CNS. Autonomic nervous system that comes under PNS maintains the involuntary activities. All these systems work together to coordinate

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adjustment and bodily reactions to internal and external surroundings. Further innovations lead to the developments of recording techniques, portable electronic devices and instruments to connect the nervous system like man-made interface. An illustration as given in figure 1 depicts PNS and brain-computer interfaces that drive prostheses.

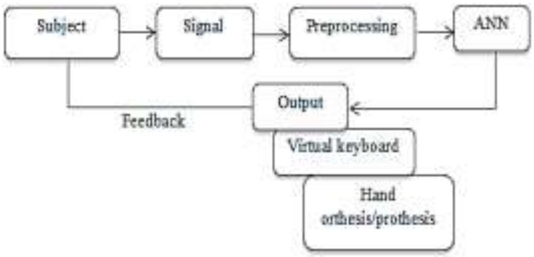

Figure 1.Man-made interface

The nervous signals from the subject are preprocessed that upgrades the classification, by which the assessed signals are interpreted correctly, where it paves way for several sort of applications. Thus feedback is driven from certain equipment via closed loop mechanism targeting the subject. Spike sorting is important in spike detection and identification and to understand the information coding within nervous tissues. A vast amount of man-made interfacing methodology is established with respect to the diversity of applications.

Thus the present article targets on techniques employing artificial neural network, machine learning, man-made interfacing and spike sorting. It concentrates on some of the methods in connection to the nervous tissue using invasive and non-invasive process, where it is oriented towards spike sorting, Functional Neuro electrical Stimulation (FNS) and Brain Computer Interfaces (BCI) in terms of artificial neural networking and machine leaning schemes.

2. CONNECTING NERVOUS TISSUE

Several strategies to connect nervous tissue are processed widely. Among them, the paper intends to review the types of brain computer interfaces and its related subjects.

2.1. Invasive BCIs

Invasive brain computer interfacing intends to repair improper sight and to provide a better system for paralyzed people. This is directly implanted in the grey matter of the brain by neurosurgical means. Such mechanisms result in generation of optimal quality signals but it declines once the body gets contacted with any foreign substance in the brain.

To cope with these difficulties, application of semiconductors came into light and thus it contributes to a greater extend since sharp needles such as Michigan and Stan-ford probes can be formed owing to its crystalline nature. These objects use Si plate of 30µm to etch them photo-lithographically. At present, in certain context, the central nervous system makes use of such electrodes to formulate brain computer interfacing. Furthermore, this strategy leads to the evolution of 3-D electrode array designs that can be permanently fixed at the cortex. Certain arrays consisting of semiconductor plate, includes needle electrodes that can be of similar or different lengths. This structure assists in investigating wider regions simultaneously in reference with different depths. Later on, invasive techniques are widely applied for brain computer interface. One such example is the Electro Cortico Graphy (ECoG), where it includes a grid of 64 electrodes located at the subdural of the cortex.

2.2. Partially invasive BCIs

Implants of partially invasive brain computer interface is done exterior to the brain which intends to generate ideal resolution output. This method is comparatively better than previously described invasive brain computer interface. An additional advantage is that its risk in developing scar-tissue is also low.

In ECoG, the electrodes are fixed in a thin plastic pad which is located between the cortex and dura-mater. It is an important intermediary brain computer interface modal quality due to its greater spatial resolution, minimal clinical risk and higher signal-to-noise proportion. [1-3] Moreover, its frequency level is larger and it requires fewer training procedures than electroencephalography. When compared to single-neuron method, it has long term stableness and considerably less technical complexities. Hence it proves to be an ideal real time method in dealing with subjects of motor disabilities.

Light reactive imaging BCI devices involve subjecting laser in the skull that is trained on a single neuron, where a sensor

measures the reflectance of the neuron. There would be a change in light form and wavelength of laser upon neuron burst, such that it paves way to check single neuron. It lowers building up of scar tissue and requires less contact with tissue.

2.3. Non-invasive BCIs

Non-invasive brain computer interface is easily wearable, yet such implants result in low quality signal resolution. Figure 2 shows the brainwaves recorded by EEG.

Figure 2.Brainwaves by EEG

EEG is the best non-invasive brain computer interface because of its fine temporal resolution. It can be handled easily, portable and less expensive. But the notable demerits are its vulnerability to noise and it also requires excess training prior to applying the strategy. An additional factor is the feedback employed that are related in fields of P300 signals. These signal forms are produced involuntarily (stimulus-feedback) when anyone sees anything. In this, no training is actually needed to recognize what the individual sees which allows brain computer interfaces to decode a sets of thoughts. On the contrary, the biofeedback approaches necessitates learning to regulate brainwaves in order to detect the resultant brain activities.

2.4. Dry active electrode arrays

The performance of arrayed electrodes is comparatively better than Ag/AgCl electrodes. Arrayed electrode includes four sensor spots with integrated electronics which reduces noise via impedance matching. It does not include any electrolyte or skin preparation. Additionally, its sensor size is small which is also compatible with that of electroencephalography monitoring structures. Active arrayed electrode is an integrated system including an array of capacitive sensors with local integrated circuit unit powered by batteries. Such integration type aids in achieving the functional results attained by the electrode.

In 1999, studies paid attention over simple techniques such us up and down, his beta-rhythm, etc. that involved quite opposite procedures other than described so far in the present paper. In these, EEG result was determined by means of software that identified noise patterns. It finds out a simple pattern to control a switch which is referred as, above average: on; and below average: off. The nerve controllers use signals to control them which also restore certain movement.

2.5. Prosthesis control

In paralyzed subjects, prosthetic upper and lower extremity tools use non-invasive brain computer interfaces that enable control of brain activities. Gert Pfurtscheller and his associates of Graz University of technology developed a brain computer interface based FES network to cure upper extremity disorder with tetraplegia caused because of spinal cord injury. [4-6] And then, around 2012, Irvine from University of California, succeeded with the brain computer interface technology to rehabilitate brain-controlled moving, after spinal cord injury. In this investigation, it was found that an individual affected by paraplegia could be able enough to drive a brain computer interfaced robotic gait orthosis to recover fundamental brain controlled movement.

2.6. Visual Evoked Potential (VEP)

Visual evoked potential is an electrical potential resulted after an individual is subjected with a form of visual stimulus. One of its types is the steady state visually evoked potential that uses the potential produced by retinal excitation, employing visual stimuli modulated at different frequencies. It originates from alternating checkerboard patterns which sometimes includes flashing images. The phase reversal frequency of the stimuli is discriminated accurately in an electroencephalography spectrum so that the steady state visually evoked potential stimuli detection becomes relatively easier and has demonstrated to perform well within several brain computer interface schemes. The reason behind this is that the signal produced is assessable in as large a group as the transient

visual evoked potential and blink movement, where the ECG components do not influence the frequencies observed. Additionally, this SS (steady state) visual evoked potential signal is extremely robust. The topographic structure of the primary visual cortex is a wider region that receives afferents from the central or fovial area of the visual field. The limitation of SSVEP corresponds with duration of the game session with respect to the flashing stimuli. Since SSVEP uses flashing stimulus to deduce the intention of the user, gazing at the flashing or iterating symbol is necessary to relate with the system. Hence this results in uneasiness for the user when the durations of the play session goes longer. [7-10] Normally, it exceeds an hour that might affect the game session. Therefore it is concluded that a novel control method must be developed that consumes limited training time and shortens the game period. Effective learning of the play mechanics and understanding the fundamental application of the BCI paradigm would be helpful.

3. SPIKE SORTING

Electrophysiological assessment uses spike sorting. Shapes that are used in spike sorting are gathered using brain electrodes in order to distinguish between the neuron activities and electrical noise. In this context, spike refers to the action potential produced by neurons during lab investigations, where this word is often applied for electrical signals noted in individual neurons' area with a microelectrode. The action potentials that deviate from baseline evolve as sharp spikes. These extracellular electrodes collect all the components including the action potentials and the synaptic currents that have minimal time. This simple process is obtained in terms of various spike sizes. It involves inaccurate type and extensive studies that makes use of the entire spike waveform. These methods work with principal components or wavelet analysis.
Multiple electrodes store several waveforms of neuronal spike in the electrode regions. It confirms that spike sorting with multiple electrodes is more effective than waveform shaped sorting. This system includes 4-micro electrodes, called tetrodes, where in certain cases it employs even more than four electrodes. On the other hand, recording electrodes are metal wires or fine print on a circuit board with gold or platinum plating at their visible tips in order to provide ideal contact and to avoid resistance changes during the investigation.

4. FUNCTIONAL NEUROELECTRICAL STIMULATION

Neurons are electrically active cells which contribute to the functional electrical stimulation. Improper effects occur due to electric current passage through nervous tissue. Some of the demerits include reduction in excitability or cell death, electroporation and generation of toxics from electrochemical reactions. [11-13] Hence adequate steps must be ensured in developing safe functional electrical stimulation, in where the clinical FES is comprised of AC or DC stimulation. In case of AC stimulation, a train of electric pulses is obtained. In addition, polarity of a biphasic pulse has dissimilar threshold for nervous tissue activation, whereas, peripheral nerves stimulation involves using cathode first pulses which results in lower threshold and higher efficiency for charge delivery.

5. CONCLUSION AND FUTURE ENHANCEMENT

Brain-wave communications tend to be a big leap in neuro-prosthetics which is similar to an individual using computer cursor to check email with his/her idea. Even monkeys could exactly move robotic arms with the help of brainwaves. One such case is the brain gate, which is an emerging brain implant method from a biotech firm, cyber kinetics that includes placing an electronic chip in the brain to monitor its activities and to convert human intention to machine commands. Considering all these factors, the present paper overviews man machine interfaces concentrating on spike sorting, FNS and BCIs. Besides the successful application of linear methods, artificial neural networks and machine learning are focused due to its better performance and upgradability mechanisms. When compared with typical strategies, ANN and machine learning proved to be a promising one in several circumstances. For instance, brain computer interfaces integrated with functional neuro-electrical stimulation of leg muscles for gait restoration is yet to be accomplished in near future. Conversely, this approach would become successful only by means of ANN and machine learning since it demands for fine-grained control that is achieved by adopting

ANN/ML. Hence, ANN/ML would become crucial in man machine interfacing fields due to its advanced technologies.

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